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ABSTRACT

This paper discusses an experiment designed to determine the effects of a problem-solving approach to instruction (PSAI) on eighth grade Algebra I students. Comparisons were made of the scores from the 1991 and 1993 Subject Area Testing Program--Algebra I of skills taught via PSAI and skills taught traditionally. In 1991 (n=56) eighth grade Algebra I students were taught seven skills traditionally and four skills via PSAI. Additional students (n=18) were taught all skills traditionally. Mean scores on the four PSAI skills were significantly higher than the mean scores on the seven skills taught traditionally. In 1993, eighth grade students (n=51) were taught all skills via PSAI and (n=44) students were taught traditionally. Mean scores showed no significant difference between performance on the four skills and the seven skills for either the PSAI or control groups. However, mean scores on the seven skills taught traditionally in 1991 but via PSAI in 1993 increased significantly. It can be concluded that utilizing a problem-solving approach to teaching Algebra I students resulted in higher mean scores. The paper includes additional evidence that the problem-solving technique helps increase retention and provides better transferability for higher level mathematics classes. (Author/MKR)

"EFFECTS OF USING A PROBLEM SOLVING APPROACH TO ALGEBRA I INSTRUCTION"

The purpose of this study was to determine the effects of a problem solving approach to instruction (PSAI) on eighth grade Algebra I students. Comparisons were made of the scores from the 1991 and 1993 Subject Area Testing Program - Algebra I of skills taught via PSAI and skills taught traditionally.

In 1991, 56 eighth grade Algebra I students were taught seven skills traditionally and four skills via PSAI. Eighteen additional students were taught all skills traditionally. An independent t-test showed the mean scores on the four PSAI skills were significantly higher ($p>.001$) than the mean scores on the seven skills taught traditionally. In 1993, 51 eighth grade students were taught all skills via PSAI and 44 students were taught traditionally. An independent t-test of mean scores showed no significant difference ($p>.05$) between the four and seven skills for either the PSAI of control groups. However, mean scores on the seven skills taught traditionally in 1991 but via PSAI in 1993 increased significantly ($p>.01$).

It can be concluded that utilizing a problem solving approach to teaching the Algebra I students resulted in higher mean scores. The paper includes additional evidence that the problem solving technique helps increase retention and provides better transferability for higher mathematics classes.

Effects of Using a Problem Solving Approach to Algebra I Instruction

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Most students do not learn mathematics effectively by only listening and imitating. They learn mathematics by discovering patterns and making conjectures based on observations (MSEB, 1989) and by actively thinking about and reflecting on what they are doing (Dick, 1988). Instead of just manipulating variables to solve a problem, students must clarify the problem, explore alternatives to the problem, use appropriate strategies and tools to solve the problem, make conjectures based on the problem and communicate the results (Carter, Charlton, Dodge, & Westgaard, 1991; National Science Board, 1983; MSEB, 1989). This process is called problem solving.

Mathematical problem solving is an extremely complex activity. It requires recall of facts, the use of a variety of skills and procedures, the ability to evaluate ones own thinking and progress while solving problems, the ability to solve problems in cooperative learning strategies, the ability to communicate mathematically, and the ability to apply various problem solving strategies to obtain solutions to various types of problems (Charles, Lester & O'Daffer, 1987; NCTM, 1989). Students involved in problem solving activities look for mathematical patterns and relationships (Borenson, 1986) and develop improved attitudes towards the subject matter, the instructional experience and in their own ability to do mathematics (Artzt & Newman, 1990). The five general goals from the National Council of Teachers of Mathematics' Curriculum and Evaluation Standards for School Mathematics (1989, 5) include having the students learn to value mathematics, become confident in their own ability to do mathematics, become mathematical problem solvers, learn to communicate mathetically, and learn to reason mathematically. The goal of this study was to quantify the effect of problem solving on mathematics learning.

METHOD

Selection of Students

In 1991, fifty-six eighth grade Algebra I students from a middle class suburban school participated in the study (treatment group). These students were enrolled in Algebra I based on their achievement in mathematics as evidenced by scoring at or above the 90th percentile on the mathematics portion of the seventh grade Stanford Achievement Test and/or on successful completion of a pre-algebra course in seventh grade. Test scores from a second group of eighteen eighth grade Algebra I students from another middle class suburban school of comparable size, SES and student diversity and with the same enrollment requirements were also analyzed (control group). In 1993, fifty-one eighth grade Algebra I students from the treatment school participated in the study, and test scores from forty-four eighth grade Algebra I students in the control school were analyzed. In 1992, eligibility for enrollment in Algebra I was changed to allow students scoring at or above the 85th percentile on the mathematics portion of the Stanford Achievement Test to enroll.

Teaching Approach

In 1991, using a method modeled by Rachlin (1987), instruction was altered to reflect a problem solving approach to instruction (PSAI). This approach utilized various teaching strategies such as group work, application of generalization, reversibility and flexibility tasks to standard problems, written explanations of process and results, and instructional techniques using games, manipulatives, group projects and activities. Students in the treatment group were taught, via PSAI, four of the eleven Algebra I skill groupings as identified by the Mississippi Subject Area Testing Program for Algebra I. These skill

groupings included translating verbal problems into equations or formulas, adding and subtracting monomials and polynomials, multiplying polynomials, and factoring polynomials. The remaining skill groupings (using the language of algebra, evaluating and simplifying expressions and equations, identifying opposites, reciprocals and absolute value, solving linear equations, using properties of exponents to simplify monomials, plotting and identifying points on a Cartesian plane and graphing linear equations, plus a category labelled other skills) were taught using a traditional lecture and demonstration method of instruction. In 1993, students were taught all skills via PSAI. Students enrolled in Algebra I in the control school were taught using a traditional lecture and demonstration method in 1991 and 1993.

RESULTS

A *t*-test for two populations means of independent samples was calculated for the 1991 means of the four Mississippi SAT - Algebra I Test skill groupings that were taught via PSAI as compared to the means of the seven skill groupings taught traditionally. Similar analyses were run on the corresponding skill groupings for the 1991 and 1993 control group means and the 1993 treatment group means. Mean scores on the four PSAI skills in 1991 were significantly higher ($p>.01$) than the mean scores on the seven skills taught traditionally (Table 1). In 1993, mean scores on the four skills originally taught via PSAI were not significantly higher ($p>.01$) than the mean scores on the remaining seven skills, which were also taught via PSAI (Table 2). An analysis of the mean scores for the seven skill groupings taught traditionally in 1991 but via PSAI in 1993 showed a significant increase ($p>.01$)(Table 3). There was no significant difference ($p<.05$) in the mean scores of the four PSAI identified skill groupings from 1991 and 1993.

Table 1

Descriptive Statistics of the PSAI and Traditional Approaches in 1991 (Experimental vs. Control Group)

GROUP	N	MEAN	STANDARD DEVIATION	STANDARD ERROR
Control				
PSAI	18	95.28	4.29	1.01
Traditional	18	93.49	3.43	.81
Treatment				
PSAI	54	91.84	2.45	.33
Traditional	54	83.53	3.85	.52

$t_{(crit)} = 2.660$ $p>.01$
$t_{(calc)}$control = 1.245
$t_{(calc)}$treatment = 8.857

Table 2

Descriptive Statistics of the PSAI and Traditional Approaches in 1993 (Experimental vs. Control Group)

GROUP	N	MEAN	STANDARD DEVIATION	STANDARD ERROR
Control				
PSAI	44	92.18	3.33	.50
Traditional	44	91.63	1.94	.29
Treatment				
PSAI	51	91.65	3.36	.47
Traditional	51	86.55	5.97	.84

$t_{(crit)} = 2.660$ $p>.01$
$t_{(calc)}$control = 1.787
$t_{(calc)}$treatment = 2.486

Table 3

Descriptive Statistics of the Change in Mean Scores in Identified Skill Groupings (1991 vs. 1993)

GROUP	N	MEAN	STANDARD DEVIATION	STANDARD ERROR
Traditional				
1991	54	83.53	3.85	.52
1993	51	86.55	5.97	.84
PSAI				
1991	54	91.84	2.45	.33
1993	51	91.65	3.36	.47

$t_{(crit)} = 2.660$ $p>.01$
$t_{(calc)}$traditional = 2.702
$t_{(calc)}$PSAI = 0.204

DISCUSSION

In 1991, scores on skill groupings taught via PSAI were significantly higher than scores on skill groupings taught traditionally. In 1993, mean scores on the seven traditional skill groupings had risen significantly, resulting in no significant difference between the original four PSAI skill groupings and the seven traditional skill groupings now taught via PSAI. It can be concluded from these results that utilizing a problem solving approach to teaching Algebra I resulted in higher mean scores.

In the treatment school, all students meeting the requirements for eighth grade Algebra I were enrolled in Algebra I. Those students desiring to take a lower level of mathematics were allowed to transfer out of Algebra I. In the control school, students meeting the requirements for eighth grade Algebra I were informed of their eligibility and were allowed to enroll in Algebra I if they desired. This subtle difference in enrollment practices led to a more heterogeneous treatment group than control group. (Out of a total eighth grade population of approximately 250 students per school, 22% of the students in the treatment school were enrolled in Algebra I as compared to 7% in the control school.)

In 1992, the standard for admission into eighth grade Algebra I was lowered from scoring at or above the 90th percentile to scoring at or above the 85th percentile. In 1993, the control school began to encourage more eligible students to enroll in Algebra I. Consequently, in 1993, the populations of students in the treatment and control groups were more similar. (Twenty percent of the student population in the treatment school and 17% of the student population in the control school were enrolled in Algebra I.) Even though eligibility standards were lowered, PSAI skill groupings showed no significant decrease in mean scores from 1991 to 1993.

In follow-up discussions and interviews with students from the 1991 and 1992 treatment classes, it appears that the problem solving strategies used by the students help increase retention and provide better transferability for higher mathematics classes. One

student, Michael D., reported that as he took a test in Algebra II, he remembered a skit that was performed two years earlier in Algebra I to teach the same skill. By remembering the actions from the skit, he was able to 'ace' the Algebra II test. Another student, Anne C., reported on a chemistry lab where data was being collected and analyzed. She recalled an Algebra I lab where spaghetti had been used to help calculate a line of best fit for some graphed data, and applied that technique to her chemistry lab. Several students have reported that, after all the analyzing and reflecting and writing they had done in Algebra I, it was very easy to learn new mathematics skills in other mathematics classes. It can be concluded from these reports that instruction in the problem solving approach to learning may have a positive impact on student retention and transferability of skills. Further research is needed to confirm or refute these observations.

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